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NOTES ON PLANT DISEASES, 1908.

By. W. J. Morse

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BULLETIN No. 164.

NOTES ON PLANT DISEASES IN 1908.

W. J. Morse.

In connection with the regular lines of investigation undertaken by the Plant Pathologists of this Station certain minor problems are encountered and studied which of themselves are not of sufficient importance to merit treatment in a separate bulletin. It also seems desirable to record observations upon the yearly prevalence and distribution of the more important plant diseases and any new or unknown troubles which appear, particularly with reference to the apple and potato, around which the major part of the work in this department now centers. This bulletin has to do with certain subjects of this nature, based largely upon the work of the current year. The following topics are considered.

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Potato Diseases of the Year.

Leaf Blights. Late blight, *Phytophthora infestans,* did practically no damage in Maine, even on unsprayed fields, during the summer of 1908. This was due to the fact that dry weather conditions prevailed over much of the State during the summer.

However, in the portions of the State where potatoes are the main commercial crop this lack of rain was not enough to reduce the crop, but just sufficient to hold the late blight in check. Early blight, *Alternaria solani,* on the contrary found ideal conditions for development upon the plants already weakened by dry weather, and consequently did much damage on all but the most thoroughly sprayed fields. This was particularly the case in the central and western parts of the State where the drouth was more severe and spraying is less generally practiced.

Stem and Tuber Diseases. Last year the occurrence of a stem and tuber disease new to Maine was noted and the appearance of the affected plants described under the name of Black-leg.*

It was stated that the evidence so far obtained indicates that the disease is of a bacterial nature. During the past summer, cultures of bacteria have been isolated from stems of potatoes attacked by black-leg, which are able to cause a rapid and complete decay of potato tubers and, on inoculation, have produced the characteristic black-leg disease of the stem, thus confirming the diagnosis. The organisms thus secured are now being studied.

Another disease of the stem and tuber which is usually designated as the Fusarium dry rot caused by the fungus *Fusarium oxysporium,* Schlecht. has been found for the first time in Maine during the past summer. It is well known that this disease, and it is probable that black-leg as well, is disseminated by means of seed tubers from infected fields, therefore, tubers from fields showing either of these diseases should not be used for seed. Fortunately neither disease is very widely distributed in Maine, and prompt measures taken at this time will restrict their spread and possibly lead to their eradication.

Both the Fusarium dry rot and black-leg are fully described in a circular issued by the Station, entitled How to Fight Potato Enemies. This circular can be obtained by any potato grower or dealer on request addressed to the Experiment Station.

Maine seed potatoes are probably as free from such diseases as any which are shipped South for planting and the writer believes that for many reasons they are much cleaner in this respect than

* Me. Exp. Sta. Bul. 149, p. 323.

those raised for like purposes in many other parts of the country. However, in order to have these conditions prevail growers and shippers of seed potatoes should at once learn to recognize both of these diseases and not knowingly ship potatoes intended for seed purposes from any fields showing either disease. If any doubt should arise as to whether either disease exists on a given field, specimens of the affected plants should be at once sent to the station.

Orchard Diseases of the Year.

On account of the appointment of Dr. Charles E. Lewis as associate pathologist, beginning July 1, it has been possible to commence certain lines of work on orchard diseases which have been under consideration since the Department of Plant Pathology was established two years ago. Comparatively little was known as to the nature and extent of Maine orchard diseases, and preliminary to opening up studies of a more fundamental nature upon the fungi associated with certain apple diseases Doctor Lewis has isolated many cultures from spots on apple leaves, collected by himself and the writer, and representing nearly every part of the State were the apple is grown to any extent. From an equally representative territory cultures have been obtained from decaying apples either on the tree or in storage. The more important results in connection with this work will be given by Doctor Lewis in a later publication.

It is sufficient at this time to say that Maine appears to have in varying degree a relatively large number of the fruit rots which have been described as occurring on the apple in different parts of the United States. Among them may be mentioned those caused by the following fungi:—*Sphaeropsis malorum* Pk. (black rot), *Glomerella rufomaculans* (Berk.) Sp. & von Schr. (bitter rot), *Sclerotinia fructigena* (Pers.) Schrt. (brown rot), *Cepholothecium roseum* Corda. (pink rot), and species of *Penicellium, Botrytis, Rhizopus* and *Alternaria.* In addition at least 4 other apple rots have been encountered, a part of which are caused either by what are apparently undescribed species of fungi or fungi which are not listed as causing apple decay.

Only preliminary work has been done in testing by inoculation of fruit with fungi isolated from leaf spots, but at least 3

of these including *Spaeropsis malorum,* have been found to produce decay of the fruit.

On account of the general lack of spraying, apple scab, caused by *Venturia inaequalis* (Cke.) Alderh., probably does more to reduce the profits from Maine orcharding than any other disease. During the winter of 1907-08 hundreds of barrels of Maine apples which were quite free from scab when placed in storage were found to be in the condition represented by Fig. 1 when taken out after six or eight weeks—quite thoroughly covered with small black specks, usually smaller than those shown in the photograph. This condition was new to the writer and none of the orchardists consulted had experienced a like trouble before.* Microscopic examination and cultures from the diseased spots invariably showed the apple scab fungus and nothing else. This abnormal development of scab was doubtless due to several factors, the principal one being that the entire growing and harvesting season was very wet, and the vegetative development of the fungus continued up to and during the harvest time. The moist apples, covered with spores, were then placed in rather warm cellars, resulting in the infection of the fruit and the formation of the small scab spots in storage.

In view of all that has been written and published on the common diseases of the apple, here mentioned, it hardly seems necessary to remind Maine orchardists that much of the loss resulting from fungi is unnecessary and can be avoided by proper and comparatively inexpensive treatment. To any who request the Station will send a circular on How to Fight Apple Enemies.

The Development of Scab Upon Limed Potato Soils.

In Bulletin No. 149 attention was called to the fact that while liming had proven very beneficial to the clover and grass crops in Aroostook County that it should be applied with caution to potato soils in short rotations on account of its liability to largely increase the amount of potato scab.† The following is a brief summary of an experiment therein reported.

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* Prof. F. C. Sears of the Mass. Agricultural College has lately told the writer that this development of scab in storage is not uncommon on stored apples in Nova Scotia.

† Me. Agr. Exp. Sta., Bul. 149, p. 316 (1907).

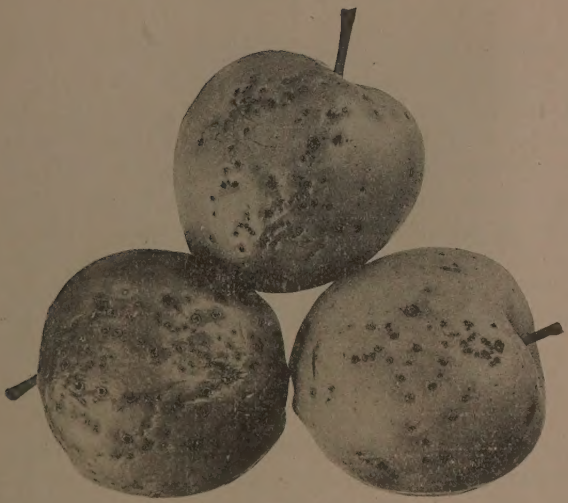

FIG. 1. Apple Scab Produced in Storage.

FIG. 2. Crotch Injury of Apple Trees.

On the John Watson farm in Houlton a series of alternate half-acre plots† were treated by the application of 1000, 500 and no lime per plot respectively, and stocked with clover and oats in the spring of 1905, an untreated check plot lying between each two limed plots. In 1907 a strip sufficiently wide to allow the planting of 5 rows of potatoes was plowed across the middle of these plots and at right angles to them. At maturity the potato crop on these plots was harvested and carefully sorted for scab, care being taken to avoid as far as possible, any cross infection or mixing of soil in the different plots. The results obtained were as follows:—

Treatment	1000 lbs. lime	500 lbs. lime	no lime
Per cent of scab on crop	49	27	11

The above results were so striking that it seemed worth while to continue the experiment for another year by replanting the same and also planting another equal strip, along side, which was in grass last season. Therefore, one series of potato rows running across the lime plots at right angles was on land which since the application of lime had been one year in oats, one year in grass and clover, and one year in potatoes fertilized with 1200 pounds of commercial fertilizer per acre and will be designated as the second year potato crop. The other given below as first year potato crop was on land adjoining and parallel to the first, like it in every way as to soil and treatment except that it had been one year in oats and two years in grass and clover since the lime was applied.

As in 1907, untreated, clean seed tubers were used for planting, and 1,200 pounds of high grade potato fertilizer applied per acre. On digging, the two rows at the junction of the potato plots were rejected as was the crop on all the rows for about 15 feet on either side of the junction of the limed with the check plots in the original grass land. In sorting, all tubers showing plainly marked scab spots were placed in that class. The following is a summary of the result obtained.

† In the previous report the plots were given, through error, as acre plots, thus making the amount of lime per acre one-half what it really was.

SECOND YEAR POTATO CROP.

Treatment	1000 lbs. lime	500 lbs. lime	no lime
Per cent of scab on crop.....	90	48	13.6

FIRST YEAR POTATO CROP.

Treatment	1000 lbs. lime	500 lbs. lime	no lime
Per cent of scab on crop	52	37	6

DISCUSSION OF RESULTS.

As in the previous year the results were quite uniform as well as clean cut and conclusive on the different plots, there being very little variation in plots receiving the same treatment. Taken together the figures obtained during both seasons seem to point to the following definite conclusions with regard to the development of scab on heavily limed Aroostook potato soils.

First, that the effect of the lime on the amount of scab is fully as great at the end of three years in grass as at the end of two years. In fact the amount of scab on the plots receiving 1000 pounds per acre was 10 per cent greater on the land laid down for three years compared with the results obtained in 1907 on similar adjoining land laid down for two years. Adjoining plots receiving 2000 pounds of lime per acre, however, have practically the same results 49 per cent and 52 per cent of scab the first year in potatoes, at the end of two and three years respectively after liming.

Second that, on limed soils, scab is largely increased by planting two successive crops of potatoes. In the present instance where a ton of lime per acre was used the per cent of scab increased from 49 per cent in 1907 to 90 per cent or almost double, in 1908, and where one-half ton of lime was used the per cent of scab increased from 27 per cent the first year to 48 per cent the second year on the same ground.

In this connection it is interesting to note that on the unlimed plots there was only a slight increase in the amount of scab the second year in potatoes, and this fully within the limits of experimental error. However, this should not be accepted as conclusive evidence for it is a matter of common observation that the second crop in succession on infected ground is as a rule more scabby than the first crop.

The first year unlimed plots showed quite a marked falling off in the amount of scab as a result of the extra year in grass. The average for these plots was 6 per cent of scabby tubers as compared with 11 per cent in 1907 and 13.6 per cent in 1908 on the adjoining second year plots.

For a discussion as to the methods of handling soil or seed to prevent the introduction of scab and the treatment of land already infested the reader is referred to the following publications of this Station: Bulletins 141 and 149 and the special circular entitled "How to Fight Potato Enemies." The former bulletin is now out of print but the two latter publications will be sent on request.

Another matter was noted in connection with the yields on the two portions of the field which is of practical importance to the potato grower. There was a marked falling off in the yields on the same land growing the second crop of potatoes in succession as compared with that growing the first crop of potatoes, although 1200 pounds of high grade potato fertilizer had been applied for each crop. The former gave slightly less than 83 per cent of a full crop as compared with the latter, or 90 and 109 barrels per acre respectively.

Self-Boiled Lime-Sulphur as a Substitute for Bordeaux Mixture for Apple Scab.

Bordeaux mixture has been found to be the most effective agent as a treatment for and as a preventative of the common leaf and fruit diseases of the apple, but unfortunately it occasionally causes injury to fruit and foliage. This matter of bordeaux injury, or "spray injury" to apple trees as it is commonly called, has been made the subject of quite exhaustive inquiry by Hedrick.* The reader is referred to his report on the subject for a detailed discussion of the nature, causes and prevalence of spray injury. With regard to the continued use of bordeaux mixture on apple trees he summarizes his conclusions as follows:—

"Bordeaux mixture is the best fungicide known to the apple grower. Its use cannot be given up in fighting the apple scab,

* Hedrick, U. P. Bordeaux Injury, Bulletin 287, N. Y. Agr. Exp. Sta., 1907.

even though it causes some injury, apple scab causes a far greater loss than Bordeaux injury."

At the same time there is need for a fungicide which will protect fruit trees from fungus diseases and yet never injure the fruit and foliage. From the published results of preliminary experiments made by Scott of the U. S. Department of Agriculture, self-boiled lime-sulphur appears to have considerable merit in this respect.† In experiments conducted at Bentonville, Arkansas, the self-boiled lime-sulphur was found to be equally as effective as bordeaux mixture in treating the bitter rot of apple caused by *Glomerella rufomoculans* (Berk.) Sp. and von Schr. It also appeared to be effective in controlling leaf-spot caused by *Sphaeropsis malorum* Pk., and caused no injury to the leaves. Its use on the more tender foliage of the peach at Koshkonong, Missouri, produced no injury and at the same time was very much more effective in controlling peach rot and scab. Bordeaux mixture, applied at the same time, was so injurious to the peach foliage that most of the leaves dropped off after the second application.

In view of the promising results recorded above it seemed advisable to at once make tests of this new fungicide as a preventative of apple scab,—*Venturia inaequalis* (Cke.) Aderh.)

Accordingly in 1908 a small orchard, consisting of about an acre, planted to four or five varieties of apples on land in Orono owned by Director Woods was very kindly set apart for these tests. As originally planned one-half of the orchard was to be sprayed with bordeaux mixture (3-3-50 formula) and one-half with self-boiled lime-sulphur mixture using hot water in preparation. However, after the first application, a letter was received from Mr. Scott advising the comparison of hot and cold water in making the latter preparation.* Therefore, one-half of the lime-sulphur plot on the second and third application was sprayed with a mixture prepared with hot water and one-half with a mixture prepared with cold water.

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† Scott, W. M. Address before the American Pomological Society, Sept., 1907. Circular No. 1. Bureau of Plant Industry, U. S. D. A., April, 1908.

* This, on account of the fact that he had found that where the lime is exceptionally good, enough sulphur can be brought into solution with hot water to slightly burn the foliage.

The lime-sulphur mixture was prepared as follows:—

15 pounds of fresh stone lime was placed in a 50 gallon barrel and a 3 gallon bucket of boiling water poured over it with constant stirring. As soon as the lime began to slake 10 pounds of sulphur was poured over it and then another bucket of water added with continual stirring with a hoe, being careful not to allow the lime to burn. When the lime appeared to be nearly all slaked but while the mixture was still boiling violently the barrel was covered with several thicknesses of burlap and then with boards, and allowed to remain closed for one hour. The mixture was then diluted, strained† the same as bordeaux mixture, made up to 50 gallons and at once sprayed on the trees. In the letter already referred to Mr. Scott stated that later experiments showed that 10 pounds of lime to 10 pounds of sulphur served the purpose as well as 15 pounds, therefore the smaller amount was used in making the mixture for the two latter sprayings.

The trees were sprayed three times,—May 14, just as the leaves were unfolding, June 10, shortly after the blossoms had fallen and again on July 6. A part of one row of trees in the center of the orchard was left unsprayed for a check. Neither spray produced any visible injury to foliage or fruit. Both adhered well to the trees, the bordeaux somewhat the best. Some of the spray in both cases could be seen on the limbs and leaves when the apples were picked, and with the Bordeaux on some trees it showed so plainly that it was necessary to wipe the fruit.

Unfortunately many of the trees of the varieties susceptible to scab failed to set fruit so that it was impossible to secure apples from several trees illustrating each treatment as was intended. The best that could be done was to select four Fameuse trees, one from each lot, bearing on an average somewhat less than a barrel apiece. The fruit was picked and very carefully sorted by a class of University students under the direction of Professor V. R. Gardner. The per cent of fruit free from scab was as follows:—

Treatment	3-3-50 bordeaux	Self-boiled lime-sulphur, hot water	Self-boiled lime-sulphur, cold water	Unsprayed check
Per cent of fruit free from scab	50	33	16	1

† A strainer with the bottom placed at an acute angle was found particularly well adapted for this purpose.

DISCUSSION OF RESULTS.

Obviously it would be unwise to draw very definite conclusions from the limited data provided above. However, taken in connection with the results obtained by Scott in treating bitter rot and leaf spot of the apple, it seems safe to conclude that self-boiled lime sulphur mixture has considerable value as a preventive of apple scab. It is at least promising enough so that any orchardist who has trouble with bordeaux injury would do well to give the lime-sulphur treatment a thorough trial.* From the comparison of single trees the lime-sulphur mixture prepared with hot water was twice as effective as that prepared with cold water, the former approaching bordeaux mixture in efficiency. Attention should be called to the fact that the percentage of scab free apples was low in all cases—even with the bordeaux mixture much below the average. In that respect the experiment was disappointing. Doubtless a 5-5-50 bordeaux would have produced better results. The large amount of scabby apples, 99%, on the unsprayed trees, indicates that the fungus was very prevalent in the orchard. If the trees had been given two extra sprayings—one early in the spring before the buds started and another about June 20—much better results might have been obtained.

Weather Records in Relation to Winter Injury of Fruit Trees.

It is well known that there is a wide variation in the ability of various plants to withstand low temperatures. Certain tropical plants have been known to die of cold at temperatures of from +35° F. to +45° F., while some arctic plants have been known to withstand cold to the extent of —76° F. With fruit trees, particularly apples, we know that there is also considerable variation in hardiness in different varieties of the same species. It is admitted that such factors as the condition of the

* Sulphur can be purchased of wholesale druggists in Bangor for 5c. per pound in 25 pound lots and 4c. per pound in 100 pound lots, therefore aside from the extra labor involved in preparation self-boiled lime sulphur mixture should cost but little more if any than bordeaux mixture.

soil, whether moist or dry, frozen or thawed, the amount of water in the tissues at the time low temperatures occur, the abruptness of temperature changes, the rapidity of thawing, the direction and character of prevailing winds, e. g. as influencing the rate of evaporation and conseuqent drying of the tissues, all enter into the question of winter-killing. It is true that these factors along with the intense cold doubtless more often cause the death of trees through stoppage of the upward water current and through its removal from the cells, or cell walls, thus bringing about conditions simulating those of drouth in summer, yet we cannot get away from the fact that: "The capacity of withstanding intense cold is a specific property of the protoplasm of certain plants*****."* There is than a certain minimum temperature below which a given variety of apples, pears, or plums, cannot be expected to endure. Therefore it is a matter of fundamental importance to the fruit grower, first to know as closely as possible the approximate zero point of a certain variety and, secondly, the probable lowest range of temperature of the region in which he wishes to plant, based upon recorded observations extending over as many years as possible. Unfortunately very little data of this nature is available, therefore it is hoped that the following article will be of some value in this respect.

Maine being on the northern limit of commercial apple growing not infrequently the orchards suffer from severe low temperatures and abrupt changes of winter weather. Prof. W. M. Munson notes that in the winters of 1903-04 and 1904-05 the orchards of the State experienced greater injury from conditions of this kind than during the twenty years immediately preceding.† With only one year for recovery this was followed by the most disastrous winter in the history of Maine orcharding, that of 1906-07. The amount of this injury is indicated by the following, quoted from a report of a census of the injured orchards carried out under the direction of Prof. E. F. Hitchings, State Entomologist and undertaken at the instance of Hon. A. W. Gilman, Commissioner of Agriculture:—

* Schimper, Dr. A. F. W., Plant-Geography upon a Physiological Basis, English Translation, p. 41. Clarendon Press, Oxford, (1903).

† Me. Agr. Exp. Sta., Bul. 128, p. 73, 1906.

"******* there were 950 orchards inspected with a total of 443,184 trees. The number killed outright was 24,613 or about 5.5 per cent. A safe estimate of the number injured would be at least 25,000 more. So that 11 per cent of the whole number of trees were killed or injured in 950 orchards." † Farther than this many of the trees which were injured did not recover sufficiently, partly on account of a heavy bearing year, following, so that they were able to withstand the following winter of 1907-08, therefore, it is probable that if the census had been taken again in the summer of 1908 the percentage of trees killed directly or indirectly by the winter of 1906-07 would have been found to be much greater than above quoted.

The writer has elsewhere discussed in some detail the causes which led to the large amount of winter killing in a single season*.. It is sufficient for our present purpose to state that after a careful inspection of the weather records at Orono throughout the fall, winter and spring of 1906-7 it seemed that conditions which preaviled for a single week near the middle of January were responsible for the injury, although it was doubtless increased by the low temperature of —28° F and —25° F recorded on Feby. 24, and March 1, respectively. Figure 3 shows graphically the daily maximum and minimum fluctuations in temperature in degrees Fahrenheit during the last 23 days of this month. The observations were made at 2 P. M., using official instruments. As a rule the minimum record is the temperature of the early morning and the maximum that at about or a little earlier than the hour of observation.

Particular attention should be called to the fact that the two lowest records of the season —40° F. and —35° F., are only 7 days apart and midway between them come two consecutive days with records of +45° F. and +47° F. Moreover these changes were quite abrupt, particularly on the 21st when from 2 P. M. to sometime before sunrise the next morning there was a fall in temperature of 60° F., or in other words a change from 15° F. *above* the freezing point to 45° F. *below* the freezing point in 12 or 15 hours. Following this in 48 hours is the sec-

† Sixth Annual Report of the Commissioner of Agriculture, p. 282, (Augusta, 1907).

* Proceedings of the Maine Pomological Society. pp. 36-46. 1907-8.

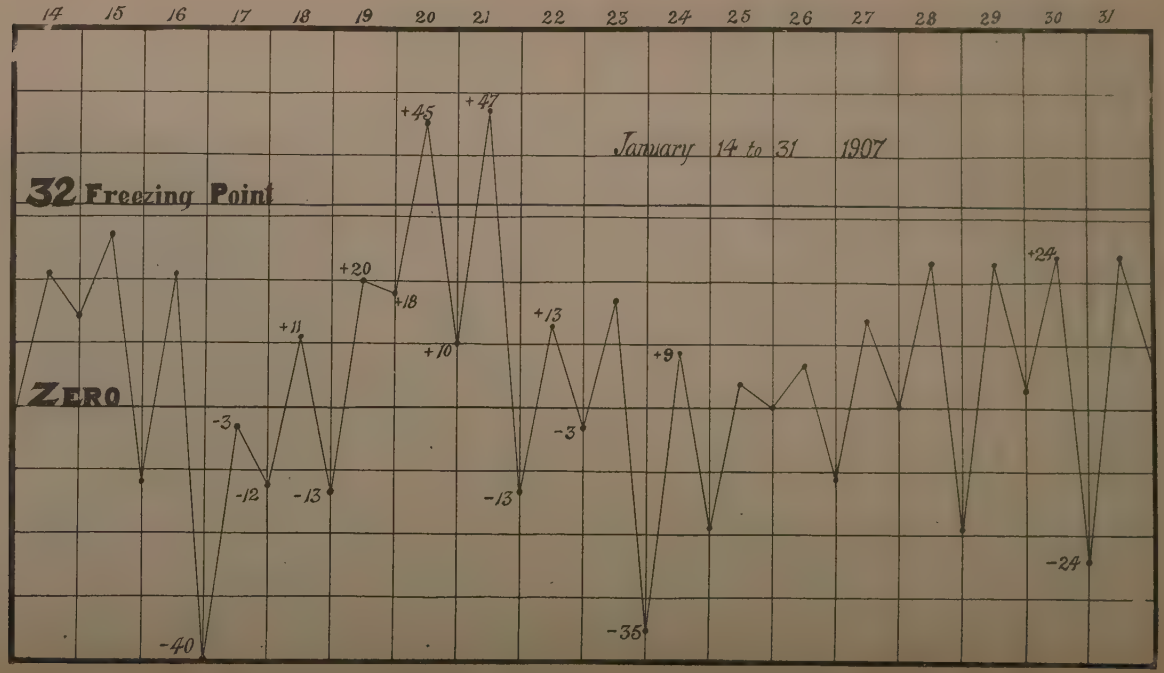

FIG. 3. Maximum and minimum temperatures in degrees F., Orono, Me., Jan. 14-31, 1907.

ond lowest record of the season, —35° F., another drop of 52° F. between observations. During the ten days following it will be seen from the figure the temperature ranged quite low, the mean for this period being only slightly above zero F. Except on the 25th these ten days were clear and the prevailing wind was northwest, although not excessive.

The weather records at Orono for nearly 40 years, 1869 to December 1, 1908, inclusive give 23 months with a minimum record of -25° or lower, these occurring in 15 different years. Only eight are -30° F. or below. January, 1878, with a minimum of -35° F. and December, 1890, with -36.3° F. are the only records through the period which in any way equal those of January, 1907, in severity. It is unfortunate that there are no authoritative records for winter-killing at hand aside from the winters of 1903-4, 1904-5, 1906-7 and 1907-8. We have the statement already quoted that the injury during the two first mentioned winters was greater than for 20 years previous. It is quite suggestive, however, to compare the records for these two winters with others in which no injury is reported. Twenty-six degrees below zero F. is given as the minimum for both January and February, 1904. Similar conditions, -27° F. for December, 1904 and -30° F. for January, 1905, are recorded for the next winter. For six years previous there had been no monthly minimum below -23° F. and for 35 years previous to this only four years, 1873, 1887, 1894 and 1898, showed two consecutive months with a minimum of -25° F. or lower, although a number of instances during the period are recorded where the minimum temperature for a single month was as low or lower than this. As has been said there are no available data to the amount of winter-killing during these years.

During the winter of 1906-07 in Maine the Baldwin and Ben Davis winter-killed much more than any other varieties, although Northern Spy, Greening and several other varieties suffered more or less severely, according to the location, slope, and drainage of the orchard. At Orono, where the weather records were taken, and at several other places, not even the hardy Russian varieties escaped without considerable injury.

It should be recognized that the above data are valuable simply as a matter of record, and any attempt to draw general

conclusions from them would be fallacious. However, taken in connection with common experience it seems safe to say that it would be a matter of considerable hazard to invest much money in attempting to grow any but the most hardy varieties of apples in those portions of the State where the lowest winter temperature frequently reaches or approximately reaches -30° F. Again it may be said that the grower who confines himself to Baldwins, and possibly Ben Davis, except in the mildest parts of the State, e. g., where the minimum winter temperature, repeated at frequent intervals, seldom reaches below -20° F., or at the utmost -25° F., must expect greater losses than his neighbor who plants most any of the other commercial varieties grown in Maine.

It is admitted that other states farther south frequently suffer nearly as much from winter killing of apples but it should also be remembered that this is probably due to frequent and abrupt changes from severe cold to mild weather, these changes being more common than is the case with the climate of Maine.

Crotch Injury of Apple Trees, Caused by Weather Conditions.

In the spring of 1907 the writer was called to Dover, Maine, to examine an orchard of about 1200-1500 trees from 8 to 12 years old. On the lower portions of this orchard many of the trees were plainly winter-killed, including 5 to 10 per cent of the whole orchard. Quite frequently trees could be found with "frost patches" or portions of the bark killed and loose on the more exposed parts of the larger limbs and trunk, but the most characteristic thing about this orchard was the constant occurrence of the crotch injury illustrated by Fig. 2. This occurred to a greater or less degree on probably 75 per cent of the trees in the orchard, the varieties being largely Ben Davis, and Stark. The bark showed every appearance of recent death, with no invasion of fungi, neither were there any scars, cankers, or other evidence of past injuries of this kind. The dead bark was drying down and cracking away from the healthy portion—it was too early in the season to see evidences of attempts to heal the wounds. The owner, an intelligent and careful

observer—a business man who for the sake of out of door work had spent all of his spare time for several years in giving this orchard his personal attention and care—was confident that nothing of this kind had appeared on *any* of the trees before.

Whetzel has shown * that not only can injuries to the bark and cambium which are usually called "sun scald" and "winter injury" be caused by the pear blight organism *Bacillus amylovorus* Burrill, but a crotch injury as well, which very closely resembles that which is here figured and discussed. It was thought at first that this was possibly the same trouble as he described, but careful observation followed up for two seasons leads to the conclusion that it is an entirely different trouble—simply an unusual form of "winter injury" or "frost patch." In this connection it should be remarked that the thousands of apple trees in Maine which in the summer and fall of 1906 appeared perfectly healthy gave ample evidence in the spring and summer of 1907 that winter-injury or frost patches are very real things and can occur independently of bacteria or fungi.†

In addition to the reasons already given the following may be cited as showing that probably adverse weather conditions and not fungi or bacteria are the cause of the crotch injury in this instance. Examination showed that crotch injury was almost universally found in previously healthy orchards which in the spring and summer following the severe winter of 1906-07 showed a large percentage of dead or dying trees. It was very common in hundreds of orchards where the injury was present largely in the form of frost patches on the limbs or trunks, but where there was every reason to believe the trees were perfectly healthy the season before. Orchards owned by the University and by Director Woods of the Station furnished excellent opportunity for personal observation upon this point. These had been given the best of care and attention. Both were in very healthy condition up to this time. There is positive evidence that there were no cankers, or dead areas on the limbs or in the crotches of these trees, previous to the winter of 1906-7. Both orchards had a large per cent of trees killed outright and nearly all which were not killed were badly injured

* Whetzel, H. H. Cornell Exp. Station, Bul. 236, 1906.

† See pages 12-17 of this bulletin.

in the crotches and showed conspicuous dead areas on the limbs and smaller portions of the trunks. In the Woods orchard a solid acre of Spys about 8 years old which were perfectly healthy in the fall showed in the spring every tree, either killed or so badly injured that they put forth a few leaves and then died. Crotch injury and frost patches were a very constant occurrence on these trees. An adjoining acre of trees 15 or more years old, largely Mildings with some Russian varieties and a few pear trees, lost only a comparatively small number, but here again the crotch injury was very prevalent, more so than frost patches on the limbs. A very noticeable fact was that in this part of the orchard whole limbs or parts of the tree were killed only on the northwest side of the trees where most exposed to the cold winds. The bark on the northwest side of the trunks on nearly all of the trees in the northern row was entirely killed, while only a few like instances could be found in the remainder of this block of trees.

Repeated attempts to isolate *B. amylovorus* from the injured crotches or limb patches only resulted in failure. Neither was there any constant association of a fungus with the patches, although various fungi, largely sapophytes, began to appear in the injured areas as the season progressed. The writer is perfectly familiar with the appearance of bacterial blight of the pear, but after spending two and one-half years in Maine, has yet to see a case of pear blight in the State, and no specimens of this disease have been sent in to the Station during that time. This indicates that while the disease without doubt occurs in the State it is by no means common.

At Orono all pear trees were killed by the winter but at Dover there were several living pear trees growing along side of the crotch-injured trees. These showed no bacterial blight during the past two seasons which would not have been the case had the organism been present in sufficient quantities to cause the amount of crotch injury which appeared in the apple orchard.

Since the crotch injury was coincident and almost invariably associated with the winter-killing resulting from the severe winter of 1906-07 and since it would seem that all other probable causes are eliminated it is fair to assume that it was in some way brought about by the same adverse weather condi-

tions. As a possible suggestion let us again refer to the weather records. We find a snow storm complicating matters just at the time of the thaw between the two low temperature records of the season. See Fig. 3, p. 15. On January 19 the maximum thermometer read +20° F. and dropped off to only 2° F. toward night, when the weather changed and by 2 P. M. the next day the temperature was +45° F. Four inches of snow fell in the afternoon and night of the 19th, but with the rising temperature this was probably of such a consistency as to load up and adhere to the trees particularly in the crotches. The storm stopped before morning, ending with a trace of rain but not enough to dispose of the snow. The thermometer dropped to +10 on the night of the 20th following the record of +45° F. On the day following it rose again to +47° F. only to fall 60 degrees F. during the night to —13° F. It seems then that the loading up of the trees with soft snow which later thawed some and suddenly froze again two days in succession, the second a very severe drop in temperature, gives conditions which may account for the crotch injury. The crotches would be filled with greater or less deposits of ice which radiated heat with more rapidity than the parts of the trunk not so covered and caused the injury described.

Correspondence with Prof. W. T. Macoun of the Central Experimental Farms, Ottawa, showed that he had observed the same trouble in various parts of the adjoining Provinces of Canada coincident with its occurrence in Maine. Without knowing that the crotch injury was being studied by the other both Prof. Macoun and the writer arrived at practically the same conclusion as to the cause, as will be seen from the following quotations kindly furnished by Professor Macoun from the forthcoming report of his Department for the year 1907.

"*Crotch Injury.*—The effects of crotch injury have been very serious in the Province of Quebec and in some parts of Ontario in recent years. On examination it is found that in the center of the crotch and on the branches diverging from it, but close to it, the bark is dead. As a result of this killing in the crotch the tree loses its strength there, rot sets in and eventually the tree is destroyed by the loss of one limb after another at the crotch. This crotch injury is probably due to ice lodging in the

crotch. There are several theories as to why the ice should cause the bark to die. One is, that it acts as a lens and concentrates the rays of the sun, causing a scalding of the bark. The position of the injured limbs alone would seem to be sufficient to show that this theory is not a good one. It seems more likely that the injury is caused by the softening of the bark by the melted snow or water before freezing, and that after freezing the bark which is, even before this probably tenderer than at any other part, owing to its being most shaded there in summer, is subjected to a severe frost and it and the cambium are both destroyed. One of the best means of preventing crotch injury is to grow trees with as little crotch as possible, training with a central leader."

Winter Injury of the White Pine in 1908.

Coincident with the large amount of winter-killing of fruit trees in Maine there has also appeared a diseased condition of the white pine, particularly of those young trees which are springing up over waste lands and abandoned pastures and which are leading to a natural reforestation of these areas. The matter has received considerable attention from the public and agricultural press of the State. This naturally led to widespread and general alarm among owners of such young pine growth, and has influenced many who were contemplating planting of pines on waste lands, to either give up the project or put it off indefinitely. This trouble has been known *popularly* as "pine blight" and apparently the term has been used to cover every condition of the tree which the observer considered to be abnormal from the normal, yearly death and shedding of the oldest set of needles on the twigs to the troubles herein described.

The general notion exists that the so-called pine blight is due to some parasitic agency, although the cause attributed is as varied as the number of writers on the subject. Fungi, various insects, gases from the sulphite mills, etc., are some of the causes assigned by different individuals in articles, correspondence or in conversation.

There appeared to be a lack of definite information on the subject, based upon careful observation of the trees in the field

over any considerable portion of white pine area of the State. Therefore, the writer has made it a point to investigate the conditions with regard to the white pine in every part of the State to which his duties called him during the past season. Many acres of pine growth were examined, distributed over and giving a pretty fair representation of that part of the State lying south of the Canadian Pacific Railroad except Franklin and Washington counties. The data thus gathered leads to the following conclusions, namely: There are two well marked leaf trouble of the white pine in Maine. One, which constituted nearly all of the so-called "pine blight" of the State in 1908, is plainly due to adverse weather conditions and while it may occur again at any time is only temporary and need not be feared like a contagious parasitic disease. The other the writer has found only in a few scattered localities, and, so far as observed during two seasons, is not spreading, at least not to an appreciable extent, and no single fungus parasite could be found constantly associated with the diseased needles. The reasons for these conclusions will be given somewhat briefly. The reader is also referred to the report for the current year (1908) of the Hon. E. E. Ring, Forest Commissioner, State of Maine.*

The discussion which follows should be distinctly understood to be confined to what has popularly been called "pine blight" in Maine and is not based on observations elsewhere in New England, although correspondence and other available information indicates that some of the trouble elsewhere may be due to similar causes.†

The common, or practically universal leaf and twig blight of the pine in Maine observed by the writer in the spring and summer of 1908 was characterized by the sudden withering and death of tufts of entire needles early in the spring, which needles soon turned a deep, rich, reddish brown. In cases of severe injury where entire trees were killed it was impossible at a distance to distinguish from scorching by fire. Young trees were invariably more severely affected

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* Morse, W. J. White Pine Blight in Maine. Rept. of Forest Commissioner for 1907-08, p. 20, Augusta, 1908.

† Clinton, G. P. Rept. 14. Conn. Exp. Sta. p. 353, 1907; Stone, G. E. Rept. 20, Mass. Exp. Sta. p. 125, 1907.

WINTER INJURY OF WHITE PINE.

Small branches photographed October 7, 1908. a-a Injured tips of the twigs from which the dead needles have fallen. b-b Tufts of young needles which started out late in the season at the base of the injury.

than old trees. In fact, all other things being equal, the younger the tree the more severe the injury. Large trees only showed scattering tufts of dead needles and these usually only on the more exposed sides. In severe cases the twigs themselves were killed back several inches. In fact acres of young trees in some parts of the State which were apparently healthy in the fall of 1907 were entirely dead by the last of May, 1908. *The most characteristic thing about the trouble was that the injury was usually confined almost wholly to the north and northwest sides of young trees growing in the open or somewhat scattered.* As a rule young trees occurring in clumps or otherwise protected were injured only on the more exposed parts. Young pines—2 to 4 feet high—were frequently observed early in May on exposed hillsides with the branches on the north and west sides of the tree and the entire top dead while the lower, more protected branches on the south side were still green and apparently uninjured.

Young pines which were badly injured when first seen in the spring were kept under observation during the summer and except in the few cases described later in this article *where the trees, like those at Brunswick, were plainly affected with an entirely different trouble,* there was no sign of disease on the needles formed the present year. The old needles and injured twigs gradually dropped off, and many trees by the first of September had the appearance of being severely pruned off on one side. About July first it was noted that in almost every case adventitious buds were showing and little tufts of new needles were forming near the base of the injury on each twig. This is shown by the accompanying photograph (Fig. 4) taken October 7. The new needles are not so long as those put forth in the spring but they are now (November 1908) entirely healthy, with no signs of disease.

Nor was this injury confined to the pines alone, for spruces and firs and some other conifers showed the same trouble and in the same manner. It was especially severe in the case of the arbor vitæ. Hedges of this tree were practically exterminated in some localities.

Microscopic examination by means of sections of the needles of affected pines and other conifers failed to show any parasitic

fungus constantly associated with the disease. In fact dead needles collected from the trees early in the season usually showed no signs of fungi of any kind.* An opportunity came to examine the roots of trees dug up out of an arbor vitæ hedge early in May. The hedge was apparently healthy in the fall before but now the foliage appeared practically dead. The roots appeared perfectly healthy when dug up and the leaves showed no sign of fungi upon them.

It seems to the writer only a logical inference to attribute the injury above described to adverse weather conditions particularly when we summarize the observations. "Pine blight" in 1907-1908 was coincident with the most destructive winter injury of fruit trees in the history of Maine orcharding. A similar trouble appeared to a greater or less extent on other conifers. The disease which constituted the major part of the trouble did not begin in particular centers and gradually spread outward from them, but appeared simultaneously in all parts of the State wherever the pine thrives. It did not appear on the young needles during the summer but came on suddenly in the early spring. Only the young and actively growing trees were badly attacked and these very much more severely on the sides exposed to the prevailing cold dry winds of winter.

While it is possible for frost coming late in the spring to cause the death of young needles,† it is very improbable that low temperatures alone were responsible for the injury in this instance. The fact that the injury recorded in 1908, the milder of the two winters, was by far the most severe and widespread is entirely against this interpretation. It is more probable that the trouble may be accounted for as the result of excessive transpiration

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* Pine needles lying on the ground were usually quite thoroughly infested with saprophytic fungi. Late in the season these fungi were found in some cases to have spread to the dead needles still adhering to the trees. Examination of needles on the same trees earlier in the season failed to show any pustules on them and no mycelium within the tissues, except in an occasional instance. Spots on the needles of pines in the State due to fungus attacks can be found quite frequently but these were by no means constantly associated with the trouble here described.

† Hartig, R. Text-book of the Diseases of Trees. English translation, by Somerville and Ward. p. 111 (London, 1894).

bringing about a condition in the plant tissues comparable to drouth in summer. Leaves on conifers remaining on throughout the year remove more or less water from the tissues all winter by transpiration. In the case of young, shallow-rooted trees the ground may be frozen to the depth and often below where the roots extend, thus effectually cutting off the upward current of water to the branches. Now if the tree is exposed to severe and long continued dry winds, particularly if accompanied by bright sunlight during a part of the day, the tissues may become sufficiently dried out in this manner as to injure them beyond recovery. The fact that the larger trees are deeper rooted, and their trunks much better protected against the radiation of heat and the consequent stoppage of the upward current in them doubtless explains in a measure why the large pines suffered only slightly as compared with younger trees.

As has already been stated there is another well marked pine leaf trouble in Maine. The writer has seen a few trees showing this disease in Brunswick, Winthrop and Orono, and has received specimens of the same thing from Lewiston. The Orono trees have been under observation for two years. The disease appeared on the young needles the second year much the same as when first observed, and in this respect as well as the general aspect of the diseased trees the trouble is decidedly diffemt from the winter injury. At Orono branches of healthy trees, interlocking with those of affected trees did not develop the disease either season. This disease is very well described in a circular issued in May 1908 by the United States Forest Service and entitled "Extent and Importance of White Pine Blight."

"Trees affected by the blight may readily be recognized from the characteristic reddish-brown color assumed by the newest needles. The tip of the needle is always affected first and needles with the base or middle turned brown but the tip green are practically never seen. The extent of the decoloration varies greatly in the different nedles, and in different trees; sometimes only the tip is affected, sometimes the whole needle. Attacked trees look as if they had been scorched by fire, or as if the tips of the needles had been dipped in reddish-brown dye.******** A tree which is attacked one year appears rarely to escape the next."

"Trees of all ages and sizes whether growing in the open or in closed stands seem to be almost equally affected, with two apparent exceptions: (1) Large full crowned trees with a diameter of 18 inches or more, standing in the open, seem to be rarely affected; and (2) trees in the interior of a dense stand seem to be more rarely affected than those near the edge. Otherwise the blight seems indifferent to the health or to the situation of the tree or to the character or moisture of the soil in which the tree is growing."

In the summary we find the following:—

"So far the disease has done but little damage, but it has now obtained such a foothold that if it proves to be infectious it may have serious results. The cause of the trouble is still unknown. The situation is not one which calls for alarm, but simply for watchfulness and investigation."

In the above discussion nothing has been said with regard to the relation of insects to the present trouble affecting the pines. Fortunately the Station Entomologist, Miss Edith M. Patch, was making the study of certain forest insects one of her important lines of investigation during the past summer. Consequently she had the opportunity and did make quite careful observations on the insects of the pine, particularly those found on diseased trees scattered over extensive and widely separated areas in the State.

In Bulletin 162, p. 366 Miss Patch after discussing various insects found upon the pine makes the following statement: "On account of the precarious condition of white pine in certain parts of the State considerable alarm has been aroused by various insects found upon the pine this season and indeed it has seemed as though an unusual number of species had taken advantage of the pines this year.

Besides the standard borers to be continually reckoned with, the pine sawflies and pine leaf eating caterpillars have made noticeable inroads, while spittle insects and plant lice (*Lachmus strobi* and *Chermes pinicorticis* have been unusually prevalent.

None of these insects, however, have been the cause of the 'white pine blight,' though several of them *Chermes pinicorticis* and spittle insects, *Aphrophora parallela*, for instance, have been in some cases conspicuously associated with the ailing trees."

BULLETIN 163.

Bulletin 163, Finances, Meteorology and Index, will be issued in March, 1909. It will contain the report of the treasurer for the fiscal year ending June 30, 1908, the meteorological report for the year ending December 31, 1908; and the index to bulletins issued in 1908. This will be sent to the Official Mailing List and to Libraries.

Copies of this bulletin (163) will be sent to any resident of Maine on application. Requests for bulletins should be addressed to the

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Orono, Maine.